

REMARKS

Claims 1-40 are pending in the current application. Claims 2-12, 14-16, 18-28, and 30-32 are withdrawn from consideration as being drawn to non-elected species, as are claims 3, 5-8, 10-12, 19, 21-24, and 26-28, which depend directly or indirectly upon withdrawn claims.

In an Office Action dated June 12, 2007, the Examiner rejected claims 1, 13, 17, and 29 under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 5,275,924 ("Devonald") in view of Published Patent Application U.S. 2002/0075557 ("Zhang1"); rejected claims 33-40 under 35 U.S.C. §103(a) as being unpatentable over Devonald in view of Zhang1, and further in view of U.S. Patent No. 6,556,470 ("Vincent"); rejected claims 1, 13, 17, and 29 under 35 U.S.C. §103(a) again as being unpatentable over Devonald in view of Published Patent Application U.S. 2002/0075420 ("Zhang2"); rejected claims 33-40 under 35 U.S.C. §103(a) as being unpatentable over Devonald in view of Zhang2, and further in view of Vincent. Applicant's representative respectfully traverses the rejections of claims 1, 13, 17, 29, and 33-40.

Based on comments and assertions made by the Examiner in the present Office Action, Applicant's representative can only conclude that the Examiner is under the misapprehension that the molecules used to form the switch assembly embodiments described in claims 1 and 17 are operated similarly to the molecules taught in the Examiner's primary reference Devonald. The Examiner is also under the misapprehension that the molecules of Devonald can be simply modified to include rotor and stator moieties taught by Zhang1 or Zhang2 in order to obtain the second monolayer of active molecules in the switch assemblies described in claims 1 and 17. However, doing as the Examiner asserts would change the principle of operation of the molecular layers taught by Devonald and render the molecules forming these layers inoperable for their intended purpose. "[T]he claimed combination cannot change the principle of operation of the primary reference or render the reference inoperable for its intended purpose." See M.P.E.P. §2145.III.

The following description is intended to aid the Examiner in understanding that the

molecules used to form the switch assembly embodiments of claims 1 and 17 are distinctly different and operated in a completely different manner than the molecules taught by Devonald. In particular, one skilled in the art would not simply modify the molecules of Devonald to include the rotor and stator moieties taught in Zhang1 and Zhang2 to obtain the second monolayer of active molecules in the switch assemblies described in claims 1 and 17.

The Examiner's primary reference, Devonald, begins by stating in col. 1, lines 5-13 that:

[t]his invention relates to a novel class of amphiphilic compounds which are particularly useful, although not exclusively so, in forming optical elements for use in optical devices with non-linear optical (NLO) properties.

The compounds of the present invention are suitable for applications that exploit second order non-linear optical properties, particularly the linear electro-optic effect.

In other words, the molecules of Devonald exhibit non-linear optical responses to applied optical fields, such as light. The molecules described by Devonald are all referred to as non-linear. It is the non-linear optical properties of the molecules that Devonald exploits in operating the devices Devonald refers to in col. 9, lines 52-68.

Nonlinear optical phenomena are "nonlinear" in the sense that these phenomena occur when a material system (*e.g.*, a molecule or molecules forming a monolayer) exhibits a nonlinear optical response to the intensity of incident light. In order to describe more precisely what is meant by the terms "nonlinear optical response," consider a mathematical representation of the polarization of a material system capable of exhibiting a non-linear optical response as follows:

$$\mu = \alpha E(t) + \beta E^2(t)$$

where α is a constant that represents the linear polarizability of the material system, β is a constant that represents the non-linear polarizability (*i.e.*, hyperpolarizability) of the material system, $E(t)$ represents the time dependent electric field component of light applied to the material system. The first term $\alpha E(t)$ is called a first order linear polarization because the electric field component has an associated exponent of "1," and

the second term $\beta E^2(t)$ is called a second-order *nonlinear* polarization because the electric field component contribution to the polarization is squared or to the power of “2.”

Second-order nonlinear interactions can only occur in non-centrosymmetric materials, that is, in materials having no inversion symmetry. For centrosymmetric materials, that is, materials having inversion symmetry, the nonlinear polarizability β is zero. For the sake of brevity and simplicity, we can assume that monochromatic light, represented by the electric field component $E = E_o \cos(\omega t)$ with an amplitude (*i.e.*, strength) E_o and a frequency ω , is incident upon a non-centrosymmetric material. Substituting the electric field component for monochromatic light into the polarization equation above gives the polarization of the material as follows:

$$\mu = \alpha E_o \cos(\omega t) + \frac{1}{2} \beta E_o^2 (1 + \cos(2\omega t))$$

The first linear term represents an induced electric dipole moment of the material that oscillates at a frequency ω , and the second nonlinear term represents an induced electric dipole that oscillates at the frequency 2ω . The above expression means that a non-centrosymmetric material can be configured to emit light with a frequency ω , and emit light with a frequency 2ω . In other words, non-centrosymmetric materials can be configured to produce a non-linear optical response by emitting light at twice the frequency 2ω of the incident light frequency. In Devonald, applying light of an appropriate intensity induces non-linear polarization, which is the principle of operation of the non-centrosymmetric molecules forming molecular layers taught by Devonald.

In Zhang1, the molecules are operated by an electric field induced rotation of at least one rotatable section (rotor moiety) of a molecule to change the electronic band gap energy of the molecule. Thus, the color switching is the result of an electric-field induced intramolecular change rather than creating emissions based on the non-linear polarization as taught by Devonald. In other words, the principle of operation of the Zhang1 molecules is via exciting electrons into relatively higher molecular orbital energy states followed by spontaneous emission resulting from the electrons transitions to lower energy states, which is completely different process than producing a light emission via non-linear polarization taught by Devonald. In Zhang1, when the rotor(s) and stator(s)

are all co-planar, the molecule is in a fully conjugated state. Thus, the π -bonding electrons of the molecule are delocalized over a large portion of the molecule. The effect is identical to that for a quantum mechanical particle in a box, where the size of the box corresponds to the size of the entire molecule, i.e., when the π -electrons are delocalized, the electronic band gap between the HOMO and LUMO is relatively small. In this case, the HOMO-LUMO band gap of the molecule is designed to yield the desired color of the ink or dye. The HOMO-LUMO band gap for the all-parallel structure can be tuned by substituting various chemical groups onto the stators and/or rotor(s). In the case where one or more rotor is rotated by 10 to 170 degrees with respect to one or more stator (nominally, 90 degrees), the conjugation of the molecule is broken and the HOMO and LUMO are no longer delocalized over the large portion of the molecule. This has the effect of shrinking the size of the box, which causes the HOMO-LUMO electronic band gap to increase. Depending on the nature of the chemical substituents bonded to the rotor(s) and stator(s), this increased HOMO-LUMO band gap will correspond to a color that is blue-shifted with respect to the color of the all-parallel structure or is even totally transparent, if the new HOMO-LUMO gap is large enough. Thus, the Zhang1 molecules are switchable between two colors or from one color to a transparent state. See paragraphs 74 and 75 of Zhang1.

Also in contrast to Devonald, Zhang2 describes a switchable medium for a visual display comprising an electric field activated bi-stable or electric-field dependent molecular system is configured within an electric field generated by a pair of electrodes. There is no mention in Zhang2 of using rotor moieties and stator moieties. Rotor moieties are portions of the molecule that rotate in the presence of an electric field and can rotate back when the field is turned off. The molecular systems of Zhang2 have an electric field induced band gap change that occurs via a change (reversible or irreversible) in conjugation. When an electric field is applied to molecular systems of Zhang2, a chemical bonding change occurs, which results in increasing or decreasing the electronic band gap of the molecules. That is to say, the molecular systems undergo bond breaking or bond making in the presence of an applied electric field, thereby inducing a change in the associated electronic band gap, wherein in a first state, there is substantial

conjugation throughout the molecular system, resulting in a relatively smaller band gap, and wherein in a second state, the substantial conjugation is destroyed, resulting in a relatively larger band gap. The two different band gaps correspond to two different light emissions. Examples of the kinds of molecules and the processes used to bring about color changes via bond breaking and making are described and shown in paragraphs 86, 91, 99, and 108. In fact, in order to change the electronic band gap of all of the molecules taught by Zhang2, an electric field is first applied to rotate a portion of the molecule into a new position where the molecule undergoes a molecular conformational change via bond breaking and bond making. Zhang2 does not teach or suggest a rotor moiety that rotates in the presence of an applied external electric field and that does not also undergo molecular conformational change via bond breaking and bond making.

A color change occurs for molecules of the present application through a molecular conformation change that alters the degree of electron conjugation across the molecule, as described above with reference to Zhang1. This change in molecular conformation is produced by applying an external electric field. For example, when no electric field is present, the molecules forming the second monolayer are conjugated and the π -orbital electrons are dissociated. Applying light of an appropriate frequency, say ω_1 , induces electrons to transitions from the HOMO to the LUMO. Electrons remain in the LUMO for a short period of time before spontaneously relaxing from the LUMO to HOMO, which in turn results in the spontaneous emission of light of a different frequency, say ω_2 . The frequency of the light emitted is different frequency of the incident light because some the light energy can be released through thermal processes such as molecular vibrations. When an electric field is applied, rotor moieties rotate with the electric field which changes the electronic configuration of the molecules. The π -orbital electrons are no longer dissociated and the energy gap between the HOMO and LUMO is larger. As a result, electrons transitions from the HOMO to the LUMO for light having a different frequency, say ω_3 , where $\omega_1 \neq \omega_3$. Again electrons remain in the LUMO for a short period of time before spontaneously relaxing from the LUMO to HOMO, which in turn results in the emission of light of another frequency, say ω_4 , where $\omega_2 \neq \omega_4$. Thus molecules forming the second

monolayer of active molecules in the switch assemblies described in claims 1 and 17 are switchable between two colors or from one color to a transparent state via electronic band gap transitions and are not operated via a non-linear second-order optical response as taught by Devonald.

Devonald teaches the use of non-centrosymmetric molecules only, in order to exploit the above described second-order optical response. This can be accomplished by applying light or an electric field to induce the second order polarization. But, the operation of molecules of Devonald is fundamentally different from that of Zhang1, Zhang2, and the molecules used to form the switch assembly embodiments described in claims 1 and 17. Devonald does not teach rotating molecular segments under the influence of an electric field (see Zhang1), and there are no molecular conformation changes brought about via bond breaking and bond making, in order to generate different optical emissions (see Zhang2). The molecules of Devonald are operated by simply applying incident light (or electric field) to produce non-linear polarization, which, in turn, causes the emission of light of a different frequency. Therefore, attempting to simply place the rotor moieties and stator moieties of Zhang1, or certain rotatable segments of molecules of Zhang2, into the molecules of Devonald as suggested by the Examiner would change the principle of operation of the molecules of Devonald.

Applicant's representative asserts that claims 1, 13, 17, and 29 are patentable under 35 U.S.C. §103(a) over Devonald in view of Zhang1 and separately over Devonald in view of Zhang2, because the Examiner has not established *prima facie* obviousness. "[I]n order [to] establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art." See M.P.E.P. §2143.03.

In the present Office Action, the Examiner asserts that the first claim elements of claims 1 and 17 regarding a first monolayer of seed molecules for initiating self-assembled molecular growth on a substrate is taught or suggested in col. 1, line 54 of Devonald. However, Applicant's representative can find no mention anywhere in col. 1, line 54 or in the remainder of Devonald of the molecules referred to by the Examiner in col. 1, line 54 are seed molecules for initiating self-assembled molecular growth. Self-assembled molecular growth can be accomplished using a broad range of different self-

assembly methods. Self-assembly methods are typically used to form a molecular monolayer on an existing molecular layer or a substrate. Devonald teaches using only Langmuir-Blodgett film deposition (see col. 1, lines 44-48 of Devonald) as only self-assembly method for forming molecular monolayers. Devonald makes no mention of using any other kind of self-assembly method. The Langmuir-Blodgett method limits the kinds the molecules that can be used to form a monolayer on an existing molecular layer or a substrate to molecules having a polar end and a non-polar end. In fact, Devonald teaches using a narrower class of the molecules than the present invention because the molecules forming the molecular layers of Devonald are *amphiphilic* (see col. 1, line 5) which are compounds consisting of molecules having a *polar* water-soluble group attached to a water-insoluble hydrocarbon (*non-polar*) chain. In contrast, the terms “self-assembled molecular growth” of claims 1 and 17 are referring to a broad range of different self-assembly methods in order to not restrict the kind of molecules that can be used to form the first monolayer of seed molecules. In particular, the molecules of a monolayer formed on the seed molecules of claims 1 and 17 are not restricted to having polar and non-polar ends.

The Examiner asserts that the second claim elements of claims 1 and 17 regarding a second monolayer of active molecules comprising a plurality of rotor moieties and stator moieties is taught or suggested by Devonald in col. 1, line 60 through col. 2, line 9. However, Applicant’s representative can find nowhere in Devonald mention of the molecules referenced by the Examiner as being rotor moieties and stator moieties. Rotor moieties of the present invention are attached to stator moieties that remain stationary while the rotor moieties rotate under the influence an externally applied electric field. There is no mention or suggestion anywhere in Devonald of employing rotor moieties and stator moieties. In fact, there is no mention or suggestion in Devonald of rotatable segments of the molecule that can be rotated under the influence of an externally applied electric field.

Therefore, claims 1 and 17 are patentable over Devonald in view of Zhang1 and are patentable over Devonald in view of Zhang2.

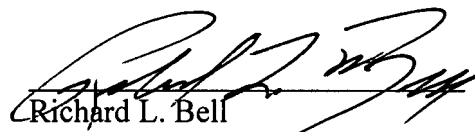
The Examiner asserts that claims 13 and 29 are unpatentable over Devonald in

view of Zhang1 and are separately unpatentable over Devonald in view of Zhang2. In both rejections, the Examiner cites Devonald col. 9, lines 52-68 as teaching that molecules of Devonald are applicable to electro-optic switching devices. However, claims 1 and 17 are patentable because the combination of Devonald and Zhang1 and the combination of Devonald and Zhang2 do not teach or suggest the claim limitations of claims 1 and 17. Furthermore, the combination of Devonald and Zhang1 and the combination of Devonald and Zhang2 change the principle of operation of Devonald. Therefore, claims 13 and 29 are patentable as depending from patentable base claims 1 and 17, respectively.

The Examiner asserts that claims 33-36 are unpatentable over Devonald in view of Zhang1 and further in view of Vincent, and separately asserts that claims 37-40 are unpatentable over Devonald in view of Zhang2 and further in view of Vincent. However, claims 1 and 17 are patentable because the combination of Devonald and Zhang1 and the combination of Devonald and Zhang2 do not teach or suggest the claim limitations of claims 1 and 17. Furthermore, as described above, combining Devonald and Zhang1 or combining Devonald and Zhang2 as asserted by the Examiner would change the principle of operation of Devonald. Therefore, claims 33-36 are patentable as depending from patentable base claim 1 and claims 37-40 are patentable as depending from patentable base claim 17.

In Applicant's representative's opinion, all of the claims remaining in the current application are clearly allowable. Favorable consideration and a Notice of Allowance are earnestly solicited.

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